

A1250-1

APRIL 9, 1990

CHEMICAL & ENGINEERING

NEWS

Top 50 chemical producers
grow only marginally last year
Page 11

Space Telescope

Instrument, soon to be launched,
will yield new view of universe

Page 4

***** 5-DIGIT 20814
0511179C090 9 K AR6815SL 0631
CONGRESSIONAL INFO SERV-SRI
SRI ACQUISITIONS
4520 EAST WEST HWY SUITE 800
BETHESDA MD 20814-3389

CHEMICAL & ENGINEERING NEWS

APRIL 9, 1990

News of the Week

■ DOE, which is seeking to formulate a national energy strategy this year, releases report summarizing issues and comments raised in hearings around the U.S. **Page 6**

■ 1st Annual Conference on Cold Fusion held recently in Salt Lake City indicates cold fusion is still alive, although many remain skeptical. **Page 6**

■ Senate passes Clean Air Act that pleases neither environmentalists nor industry; lobbying efforts now focus on House. **Page 7**

■ Conoco to buy 400 houses and residential lots to settle suit by residents of Ponca City, Okla., who claimed groundwater contamination by hydrocarbons from company's oil refinery. **Page 7**

Business

Top 50 chemical production edged up only 0.2% in 1989, just past the 1988 all-time high, to a new record of 611 billion lb. **Page 11**

Overall output of polymers—plastics, synthetic fibers, and synthetic rubber—slipped 2% last year, the first decline in seven years. **Page 14**

Government

Transport of food products and chemicals back-to-back in same vehicles would be prohibited by House legislation approved last month. **Page 17**

Yale protein chemist may head inquiry that is being set up by NIH into events leading to discovery of AIDS virus. **Page 18**

Science/Technology

Density-functional theory gains following among chemists as it improves quantum chemical calculations of large molecules, transition-metal compounds, organometallics. **Page 22**

Cover: Hubble Space Telescope during preflight testing at Lockheed Missiles & Space Co.
Photo courtesy of NASA

Letters	2
Concentrates	
Business	9
Government	16
Science/Technology	20
The Departments	
Meetings	31
New Products	45
Newsprints	70



Cover Story

Hubble Space Telescope, to be launched from space shuttle scheduled to blast off on April 10, is first of four "great observatories" to be launched by NASA; several instruments making chemically related measurements are included in the package. **Page 4**

Chemical & Engineering News

1155—16th St., N.W., Washington, D.C. 20036

Editor: Michael Heylin

Assistant Managing Editors: David M. Kiefer, James H. Krieger, Janice R. Long, Donald J. Soisson, William J. Storck. News Editor: Wilbert C. Lepkowski

Staff Editor: Ernest L. Carpenter

Senior Editors: New York: Earl V. Anderson, Stephen C. Stinson; Chicago: Joseph Haggins; London: Patricia L. Layman; Washington: Doron Dagan, Lois R. Ember, Bette Hileman, Rebecca L. Rawls, Pamela S. Zurer

Associate Editors: Stuart A. Borman, Mairin B. Brennan, Ann Marie Menting, Richard J. Seltzer

Service Departments Editor: Dolores Miner

Editing Services: Anne Riesberg (Head), Arlene Goldberg-Gist (Editorial Assistant), Patricia Oates (Administrative Assistant)

News Bureaus: Northeast News Bureau: (201) 906-8300 Marc S. Reisch (Associate Editor), Ann M. Thayer (Associate Editor), Rachel Eskenazi (Administrative Assistant). Chicago: (708) 256-4143 Ward Worthly (Head). Houston: (713) 973-8161 Bruce F. Greek (Head), Susan J. Ainsworth, (Associate Editor). Washington: (202) 872-4495 David J. Hanson (Head). West Coast: (415) 653-3630 Rudy M. Baum (Head). Foreign Bureau: London: (01) 540-0414 Dermot A. O'Sullivan (Head)

Graphics and Production: Leroy Corcoran (Head). Alan Kahan (Art Director). Barbara Fryer (Production/Art Director). Linda Mattingly (Staff Artist). Diane Kelly (Costing)

Business Manager: Arthur Poulos

Circulation Development: Claud K. Robinson

ADVISORY BOARD: Dexter F. Baker, George M. Bodner, Will D. Carpenter, Renée G. Ford, Ethan C. Galloway, Louis J. Glunz, Harry S. Hertz, Christopher T. Hill, Kendall N. Houk, Cynthia A. Maryanoff, Linda B. McGown, C. Bradley Moore, Koji Nakamishi, George B. Rathmann, David A. Shirley, Robert M. Simon, Peter H. Spitz, Barry M. Trost

Published by

AMERICAN CHEMICAL SOCIETY

(202) 872-4600; TDD (202) 872-8733

John K. Crum, Executive Director

Robert H. Marks, Director, Publications Division

PUBLISHING BOARD: Jeanne M. Shreeve

(Chairman); Board of Directors Chairman: Joseph A. Dixon; President: Paul G. Gassman; Richard L. Deming; William P. Jencks; Gary J. Long; and Louis D. Quin

© Copyright 1990, American Chemical Society

Subscription & Member Record Service: Send all new and renewal subscriptions with payments to: Controller, ACS, P.O. Box 28597, Central Station, Washington, D.C. 20005. Correspondence and telephone calls for changes of address, claims for missing issues, subscription service, status of records and accounts should be directed to: Manager, Member & Subscriber Services, ACS, P.O. Box 3337, Columbus, Ohio 43210; (800) 333-9511 or (614) 447-3776.

For changes of address, include both old and new addresses with ZIP code numbers and mailing label from a recent issue. Allow four weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America: more than 90 days beyond issue date, (b) all other foreign: more than one year beyond issue date; or if the reason given is "missing from files."

Subscription Rates 1990. Printed editions: nonmembers U.S. 1 yr. \$60, 2 yr. \$108, outside U.S. 1 yr. \$93, 2 yr. \$174. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current \$9.00. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management

CENTCOM LTD.
(For list of offices see page 69)

LETTERS

Remembering Bill Bailey

SIR: I was shocked to read of the untimely death of Bill Bailey (C&EN, Jan. 1, page 7).

I, too, was an undergraduate student at the University of Maryland and remember Bailey well. In the early 1950s I was a student in his sophomore organic class, an assignment he had recently taken over from Nathan Drake. I recall very well the help he provided in getting a drowning organic student back on track. During 29 years of teaching organic chemistry to students at Ohio University, I have often confessed my initial difficulties with the subject and how vital it had been for me to take the initiative to get some help from the instructor. I know that my understanding of the troubles students encounter can be traced in part to my own experience, and that Bill Bailey's concern for me then has influenced greatly how I have dealt with students over these years.

I remember too the very special twinkle in his eyes as he discussed chemistry with me, indicating not only his love for the subject, but also the special, good-natured way he worked with people. He will be greatly missed.

Robert R. Winkler
Department of Chemistry
Ohio University

NSF chemistry grants

SIR: Janice Long and Pamela Zurer are to be commended for trying to find a silver lining in the storm clouds when they describe the 1991 budget request for the National Science Foundation's chemistry division (C&EN, Feb. 12, page 11): "The new budget request is... lower than that submitted for fiscal 1990. Still, the chemistry division manages to fund about 58% of the proposals it receives." Unfortunately, the silver lining is an artifact of the bookkeeping terminology NSF used in the budget request to Congress.

In fact, the chemistry division funds only about one third of reviewed research proposals it receives. The confusion comes... because most chemistry division year continuing... article not covered... time and third-year automatic... awards. A request's... continuously... never externally...

there were 597 such continuing grant amendments paid by the chemistry division.

In fiscal year 1989, the chemistry division made 275 research grants, including Presidential Young Investigator Awards, from 832 reviewed research proposals—a 33% success rate. These figures include both new and renewal applications for research project support, but exclude the shared instrumental program (49% success rate), instrumentation and laboratory improvement (18%), research experiences for undergraduates (15% for sites), and postdoctoral research fellowships in chemistry (13%).

K. N. Houk
K. G. Hancock
Chemistry Division
National Science Foundation

Chemical education

SIR: Concern for the general state of chemical education, as in the ACS president's speech (C&EN, Jan. 1, page 2) and the Congressional Outlook article (C&EN, Jan. 8, page 8), often suggests remedial action that is marginal or indirect—as when the focus is on organization and funding. Easily overlooked in major pronouncements are insights such as those of Roald Hoffmann in his talk at PACIFICHEM '89 (C&EN, Jan. 1, page 6). Some of us who have become directly involved with introductory chemistry agree with his comments that most introductory chemistry instruction alienates students from science and develops an attitude that is not the basis for democracy. The list of those who suffer begins with the individual student and runs through and beyond the chemical profession.

From their introductory chemistry experiences, most students learn that the world is not understandable; that is, they learn that they themselves cannot understand it. They find that they are not even encouraged or expected to understand it! They should learn what others—teachers, textbook writers, or scientists—say. Students tell me, sometimes belligerently, "How should I know, that's just what my teacher told me." Although there is no direct path from this attitude to a general acceptance of off-pronouncements, we have missed chance to foster dependence on the

Correction

• March 26, page 13: Iraq, not Iran, is one of the three nations known to possess chemical weapons.

Top 50 Chemicals Production Slowed Markedly Last Year

Output increased only 0.2% to 611 billion lb; inorganics production moved up a modest 2%, while organics faltered, slipping 3.3% from 1988

Marc S. Reisch,
C&EN Northeast News Bureau

Although chemical exports and domestic demand started strong in 1989, an economic slowdown in the second half of the year put the brakes on industry production. According to C&EN's annual ranking of the 50 largest volume chemical

products, total production in that group in 1989 increased only 0.2% from 1988. Production just eked past the 1988 all-time high to a new record high of 611 billion lb.

As 1988 ended with record demand for most chemical products, new capital projects began to come on stream during 1989. But demand did not materialize to absorb all of the industry's output. According to seasonally adjusted Federal Reserve Board data, chemicals and allied products output rose 1.8% between the first and fourth quarter of 1989, while industry capacity rose 3.9%. Concurrently, industry capacity use fell from 88.9% in first-quarter 1989 to 87% in the fourth quarter.

As more product became available during the second half of 1989, prices finally eased. Labor Department statistics show that prices for chemicals and allied products peaked in April and May of 1989 at an index of 124.9 (1982 = 100). By December the chemicals and allied products index had dropped to 118.6, down 2.5% from a year earlier. Still, December 1989 prices were 7.2% above those in January 1988. The industrial chemicals subcategory illustrates the same trend. The producer price index for that category peaked in May 1989 at 117.8 and declined 3% by December, having dropped as low as 4.9% off the May peak in November. However, the December 1989 index for the

About the Top 50 list of chemical products

Government data, trade association figures, and industry estimates all go into preparing C&EN's annual list of the Top 50 chemical products, ranked by production volume. The federal government is relied upon most heavily, but when government figures are not available, other sources, primarily trade associations, are used. Industry sources and C&EN estimates are used only when other data are lacking.

Government data are not always accurate—they are only as good as the information that individual companies report. But they are an objective measure of production extending back many years. Therefore, relatively accurate indications of growth can be made on a consistent basis.

At this time of year, C&EN has access only to preliminary reports of production for 1989. When the government and trade associations issue their final reports, the outcome can be changed, sometimes dramatically. As a result, the production figures for earlier

years that appear in the table on page 12 are different in some cases from those published in last year's Top 50 article. The final reports also can affect the rankings of chemicals. For the table published on page 12, the 1988 ranking of 22 chemicals is different from last year's listing (C&EN, April 10, 1989, page 12). Production revisions affected the 1987 ranking of only one chemical in the table appearing last year.

The list itself covers production figures for the U.S. and includes chemicals produced for export. Candidates for the list include all basic, intermediate, and chemically homogeneous finished products. These range from chemical building blocks like ethylene and propylene to downstream products like vinyl acetate and ethylene glycol.

The roster also includes basic inorganic chemicals but does not include what C&EN considers to be minerals, such as salt, gypsum, and sulfur. Lime is included because it is processed and has many chemical and industrial appli-

cations. Refractory (dead burned) dolomite is excluded in lime production.

In the organics list, such petrochemical feedstocks as ethane, butane, and propane are excluded arbitrarily because they are considered to be products of oil companies and because they have many nonchemical uses.

There are other gray areas besides lime and petrochemical feedstocks. For example, the basic aromatics—benzene, toluene, and xylene—are included.

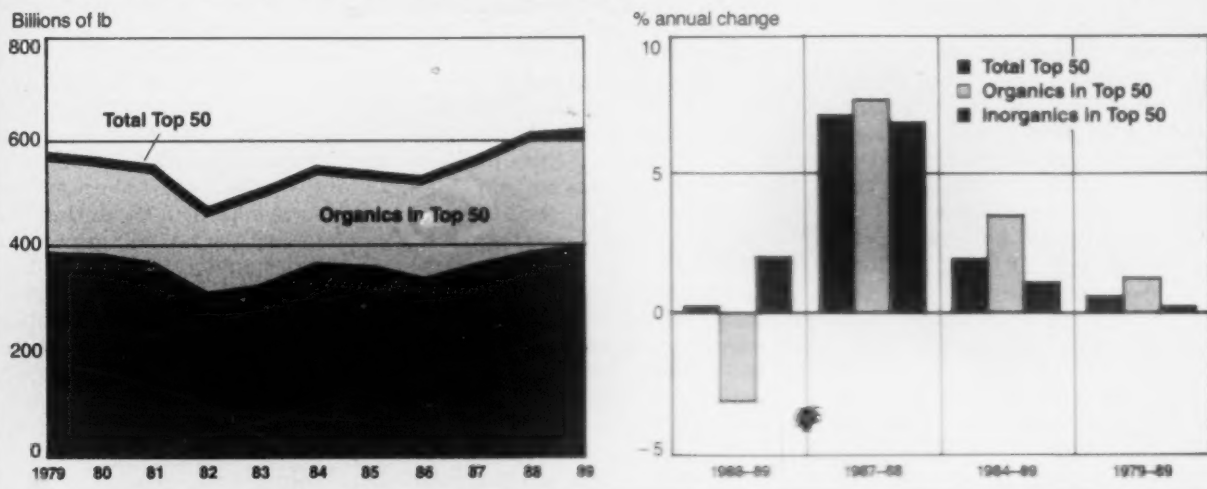
Production figures are published by the government in a variety of units—pounds, tons, cubic feet, gallons, metric tons, and, most recently, kilograms and liters. Where the latter two units are used, they have been converted into the common units that the government and industry have historically used as points of reference. To provide an accurate ranking and to make comparison of production volumes easier, C&EN lists production not only in common units, but converted to pounds.

Top 50 chemicals production totaled about 611 billion lb in 1989

Rank			Billions of lb		Common units ^b		Average annual growth			
1989	1988 ^a		1989	1988	1989	1988	1988-89	1987-88	1984-88	1978-88
1	1	Sulfuric acid	86.80	84.28	43,399 tt	42,141 tt	3.0%	7.3%	0.8%	0%
2	2	Nitrogen	53.77	52.32	742 bcf	722 bcf	2.8	10.4	2.3	5.7
3	3	Oxygen	37.75	37.42	456 bcf	452 bcf	0.9	15.9	3.4	0
4	4	Ethylene	34.95	37.20	34,953 mp	37,203 mp	-6.0	6.3	2.2	1.6
5	5	Ammonia	33.76	33.64	16,878 tt	16,821 tt	0.3	4.1	0.2	-1.0
6	6	Lime ^c	32.99	32.02	16,495 tt	16,011 tt	3.0	5.5	0.6	-2.4
7	7	Phosphoric acid	23.12	23.35	11,559 tt	11,877 tt	-1.0	11.5	0.3	1.1
8	8	Chlorine	22.32	22.51	11,161 tt	11,257 tt	-0.9	2.5	0.8	-0.9
9	10	Sodium hydroxide	22.15	21.05	11,075 tt	10,527 tt	5.2	-8.6	0.3	-1.4
10	9	Propylene	20.23	21.22	20,229 mp	21,224 mp	-4.7	14.6	5.4	3.6
11	11	Sodium carbonate ^d	19.79	19.26	9,896 tt	9,632 tt	2.7	8.3	3.1	1.8
12	12	Nitric acid	15.98	15.98	7,991 tt	7,991 tt	0	12.5	0.7	-1.1
13	13	Urea ^e	15.47	15.83	7,733 tt	7,914 tt	-2.3	6.4	0.8	1.0
14	14	Ammonium nitrate ^f	15.11	15.01	7,557 tt	7,504 tt	0.7	17.0	1.1	-0.9
15	15	Ethylene dichloride	13.68	13.03	13,675 mp	13,028 mp	5.0	-5.6	5.0	1.5
16	16	Benzene	11.67	11.73	1,585 mg	1,593 mg	-0.5	0.5	3.8	-0.5
17	18	Carbon dioxide ^g	10.83	10.12	5,413 tt	5,058 tt	7.0	2.6	3.5	6.1
18	20	Vinyl chloride	9.82	9.06	9,618 mp	9,058 mp	6.2	10.1	9.6	4.2
19	19	Ethylbenzene	9.22	9.93	9,223 mp	9,929 mp	-7.1	5.5	4.1	0.9
20	17	Terephthalic acid ^h	8.31	10.23	8,309 mp	10,234 mp	-18.8	26.2	7.0	3.0
21	21	Styrene	8.13	8.98	8,129 mp	8,984 mp	-9.5	11.1	1.1	0.8
22	22	Methanol	7.14	8.14	7,139 mp	8,142 mp	-12.3	11.7	-2.7	-0.3
23	24	Formaldehyde ⁱ	6.37	6.28	6,370 mp	6,280 mp	1.4	3.3	1.8	0.6
24	23	Toluene ^j	5.84	6.35	805 mg	875 mg	-8.0	-5.7	2.0	-2.2
25	29	Xylene	5.80	5.48	805 mg	761 mg	5.8	-4.3	-1.2	-1.9
26	28	Ethylene glycol	5.50	5.52	5,499 mp	5,517 mp	-0.3	22.2	2.7	1.5
27	27	p-Xylene	5.49	5.60	5,494 mp	5,601 mp	-1.9	8.7	5.2	1.7
28	25	Ethylene oxide	5.32	5.95	5,322 mp	5,953 mp	-10.6	5.9	-1.4	-0.8
29	30	Hydrochloric acid	5.26	5.28	2,628 tt	2,640 tt	-0.5	-11.9	-0.5	-1.6
30	26	Methyl tert-butyl ether ^k	4.96	5.68	4,976 mp	5,680 mp	-12.4	68.4	29.3	na
31	31	Ammonium sulfate	4.71	4.67	2,354 tt	2,333 tt	0.9	6.9	2.6	0
32	32	Cumene	4.54	4.46	4,535 mp	4,455 mp	1.8	7.3	3.9	1.5
33	33	Phenol ^l	3.89	3.56	3,893 mp	3,562 mp	9.3	9.9	6.1	2.7
34	36	Acetic acid	3.83	3.16	3,826 mp	3,159 mp	21.1	-2.1	7.9	1.6
35	34	Potash ^m	3.35	3.35	1,521 tmt	1,521 tmt	0	20.5	-0.6	-3.7
36	37	Propylene oxide	3.20	3.11	3,200 mp	3,110 mp	2.9	19.2	12.5	3.6
37	35	Butadiene ⁿ	3.09	3.17	3,094 mp	3,169 mp	-2.4	5.6	4.8	-1.5
38	38	Carbon black	2.91	2.92	2,913 mp	2,916 mp	-0.1	7.0	0.1	-1.3
39	39	Acrylonitrile	2.61	2.61	2,608 mp	2,609 mp	0	2.3	3.3	2.6
40	42	Acetone	2.50	2.30	2,497 mp	2,303 mp	8.4	10.6	6.0	-0.6
41	40	Vinyl acetate	2.47	2.56	2,470 mp	2,561 mp	-3.6	2.2	4.1	2.2
42	42	Cyclohexane	2.39	2.30	2,389 mp	2,297 mp	4.0	2.1	3.7	-0.1
43	41	Aluminum sulfate	2.35	2.46	1,173 tt	1,232 tt	-4.8	0.7	0.8	-1.1
44	44	Titanium dioxide	2.22	2.04	1,110 tt	1,022 tt	8.6	7.4	5.9	4.1
45	48	Calcium chloride ^o	1.92	1.46	960 tt	729 tt	31.7	-5.7	-1.8	-0.2
46	46	Sodium silicate	1.75	1.62	877 tt	812 tt	8.0	-14.7	5.1	0.8
47	47	Adipic acid	1.64	1.60	1,640 mp	1,600 mp	2.5	1.8	3.4	-0.6
48	45	Sodium sulfate ^p	1.60	1.63	800 tt	817 tt	-2.1	1.5	-1.7	-3.3
49	49	Isopropyl alcohol	1.43	1.39	1,432 mp	1,389 mp	3.1	5.8	0.5	-2.8
50	50	Caprolactam	1.31	1.26	1,312 mp	1,261 mp	4.0	8.6	5.0	3.3
TOTAL ORGANICS			210.61	217.66			-3.3%	7.8%	3.6%	1.4%
TOTAL INORGANICS			400.44	392.41			2.0%	7.0%	1.3%	0.2%
GRAND TOTAL			611.04	610.11			0.2%	7.3%	2.0%	0.6%

a Revised. b tt = thousands of tons, bcf = billions of cubic feet, mp = millions of pounds, mg = millions of gallons, tmt = thousands of metric tons. c Except refractory dolomite. d Natural and synthetic. e 100% basis. f Original solution. g Liquid and solid only. h Includes both acid and ester without double counting. i 37% by weight. j All grades. k Production data for earlier years unavailable. l Synthetic only. m K₂O basis. n Rubber grade. o Solid and liquid. p High and low purity. na = not available.

Production of Top 50 chemicals up marginally



industrial chemicals subcategory was 15% above the producer price index in January 1988.

To be sure, the price of available chemical product was not entirely the creature of supply and demand. Labor costs and energy prices in late 1989 were higher than in 1988. For instance, Department of Labor statistics show that chemical industry production worker earnings increased 4.1% between December 1988 and December 1989, and the producer price for crude oil gained 35% during the same period of time, according to the Commerce Department. It is easy, then, to understand why the industry finds itself in an earnings slowdown (C&EN, Feb. 19, page 10), as the moderation in demand for its largest volume products in 1989 was accompanied by a decline in prices even as labor and energy costs increased.

Slow demand from traditional large chemical industry customers also has hurt the chemical industry. Domestic motor vehicle output declined 22.5% in the fourth quarter of 1989 from the third quarter, following a moderate decline in the third quarter, notes the Commerce Department. New housing starts continued slow last year. Fertilizer demand remained fairly strong. Exports held up better than expected in 1989, but did not take up the slack from slowdowns in domestic demand.

Among the largest volume chemi-

cals produced in the U.S., sulfuric acid remained on top with total production of 86.8 billion lb, a 3.0% increase from 1988. Nitrogen continued to rank a distant second, with production at 53.8 billion lb, up 2.8% from 1988. In both cases, the rate of increase in production slowed considerably from the previous year when the rise in sulfuric acid production was 7.3% and that in nitrogen production was 10%.

Organic chemicals, making up some 34% of the Top 50, did not make nearly as good a showing in 1989 as they did in 1988. Their production actually decreased 3.3% from 1988 when the organic chemicals category made up some 36% of the Top 50 and had grown 7.8% from the previous year. Over the five-year period 1984-89, production of organic chemicals among the Top 50 increased an average of 3.6% a year. Historically their output has grown at a much slower pace. Between 1979 and 1989, output of organic chemicals among the Top 50 grew at a compound annual rate of only 1.4% a year.

By contrast, the inorganic segment of the Top 50 increased its production in 1989. Output for that category rose 2.0% from 1988, when production grew at a faster clip, 7.0%, compared with the year earlier. Over the five-year period 1984-89, production of organic chemicals among the Top 50 increased at an average 1.3% a year. Historically,

output for the group has grown at an even slower pace than that of the organics in the Top 50. Between 1979 and 1989, output of inorganic chemicals among the Top 50 grew at an annual rate of only 0.2%.

Of the Top 50 chemicals, production of 26 of them increased in 1989. By contrast, production of 42 increased in 1988. Total production of the Top 50 chemicals, at 611 billion lb, was up a mere 0.2% from 1988 compared with the 7.3% growth for the whole group from 1987 to 1988. However, the 1989 level of production just managed to edge past the historic high set last year at 610 billion lb. Still, the 1989 production level was 32% higher than the decade-low level of 464 billion lb registered in 1982.

For the Top 50 group, composite output increased at a compound annual rate of 2.0% between 1984 and 1989. Long-term growth for the group as a whole was an even slower pace: Between 1979 and 1989, Top 50 production grew at an average annual rate of 0.6%.

Leading the inorganics' production gains was calcium chloride, up 32% from 1988 to 1.9 billion lb. The gain pushed calcium chloride from 48th place in 1988 to 45th place in the 1989 rankings. The calcium chloride data from 1987 and 1988 may not be entirely accurate; a statistician for the Bureau of Mines notes some problems in collecting and compiling figures for earlier years. Accord-

ing to data available, calcium chloride production has declined at a compound annual rate of 0.2% between 1979 and 1989.

The next largest gain among inorganics was by titanium dioxide, up 8.6% to 2.2 billion lb. The gain placed it in 44th place, the same ranking it occupied in 1988 when output increased 7.4%. Sodium silicate production recovered in 1989 following a drop the previous year; output increased 8.0% to 1.2 billion lb following a 15% drop in 1988. The gain placed the chemical in 46th place, the same ranking it occupied in 1988.

Although the inorganics showed the best performance as a group in 1989, some were significant under-achievers. Aluminum sulfate pro-

duction declined 4.8% in 1989 to 2.4 billion lb, compared with a 0.7% increase in 1988. And sodium sulfate production declined 2.1% to 1.6 billion lb in contrast with a 1.5% increase in the previous year.

For organic chemicals, 1989 production growth was led by acetic acid, up 21% to 3.8 billion lb. As a result, acetic acid moved from 36th place to 34th place in the 1989 list. Phenol also showed good growth, up 9.3% to 3.9 billion lb, but remained in 33rd place. The next largest gainer in the organics category was acetone, up 8.4% to 2.5 billion lb in 1989 and into 40th place.

Components of the organic chemicals group among the Top 50 showed the largest year-to-year declines in 1989 of all 50 chemicals.

The most dramatic was a 19% drop for terephthalic acid to 8.3 billion lb. In 1988, production of the chemical increased 26% to 10.2 billion lb.

Looking at growth over the past 10 years, 24 of the Top 50 chemicals have recorded overall production increases. The best long-term performer has been carbon dioxide, output of which grew at an annual compound rate of 6.1% during the period. Nitrogen has also grown at a good rate, 5.7%. Other chemicals with sizable annual growth rates were vinyl chloride, 4.2%; titanium dioxide, 4.1%; propylene oxide, 3.6%; and propylene, 3.6%. Potash registered the largest average annual rate of decline over the past 10 years, with output falling at a compound annual rate of 3.7%. □

Polymer output dips for first time in seven years

Overall U.S. production of commercial polymers, including plastics, synthetic fibers, and synthetic rubber, declined 2.0% in 1989 from a year earlier. The decline was the first in seven years and put total 1989 polymer output at 59.3 billion lb following the 60.5 billion lb record output of 1988.

Plastics output, which accounted for more than three quarters of the polymer group production total, declined 2.2% in 1989. In 1988, plastics production grew 6.8% from 1987.

The decline in U.S. plastics pro-

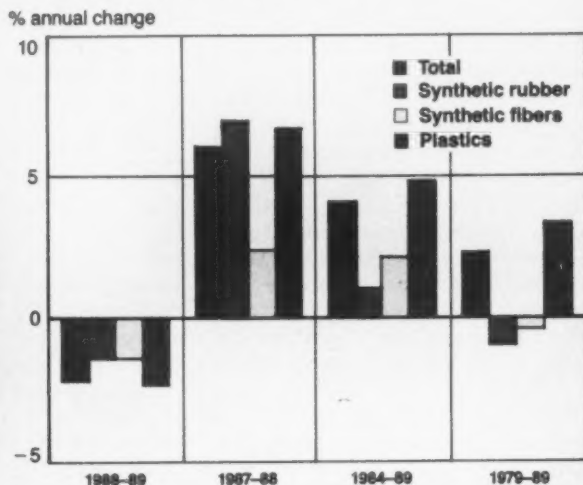
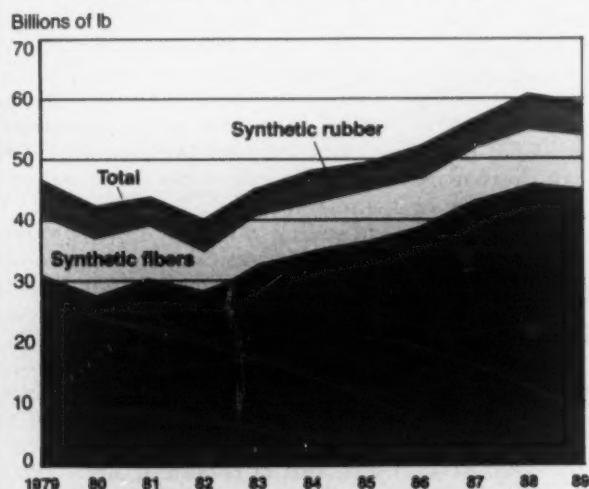
duction might have been greater if the volume of exports had not grown so dramatically as it did in a number of categories. Export growth was particularly strong for unsaturated polyester resins (up 53% to 24.2 million lb), high-density polyethylene (up 42% to 921 million lb), polystyrene (up 39% to 224 million lb), and polyvinyl chloride and copolymers (up 77% to 913 million lb).

Within the plastics category, thermoplastics production dropped 2.1% but showed less of an overall decline than thermosetting resins, pro-

duction of which declined 3.0%. Among the thermoplastics, polyvinyl chloride and copolymers registered modest growth of 1.7%, and polypropylene production edged up 1.1%. All the other resins within the grouping showed a decline. The most dramatic decline in production was for low-density polyethylene, down 6.4%, followed by high-density polyethylene, down 3.6%, and then polystyrene, down 1.6%.

Among the thermosetting resins, melamine put in a surprisingly strong showing, up almost 11%.

Output of plastics, synthetic fibers, and synthetic rubber declined in 1989



Total polymer output exceeded 59 billion lb last year

	Billions of lb		Common units					Average annual growth			
	1988	1989	1989	1988	1987	1984	1979	1986-88	1987-88	1984-88	1979-88
PLASTICS (millions of lb)											
Thermosetting resins	6.39	6.59	6,388	6,588	6,265	5,549	4,856	-3.0%	5.2%	2.9%	2.8%
Phenol and other tar acid resins	2.86	3.07	2,862	3,068	2,870	2,502	1,781	-6.7	6.8	2.7	4.9
Urea resins	1.47	1.43	1,469	1,425	1,382	1,199	1,367	3.1	3.1	4.1	0.7
Polyesters (unsaturated)	1.32	1.40	1,319	1,404	1,368	1,232	1,147	-6.1	2.6	1.4	1.4
Epoxies (unmodified)	0.51	0.49	509	488	433	406	361	4.7	12.2	4.6	3.5
Melamine resins	0.23	0.21	229	207	212	210	200	10.6	-2.4	1.7	1.4
Thermoplastic resins	38.77	39.61	38,772	39,608	36,992	30,036	26,768	-2.1%	7.1%	5.2%	3.8%
Low-density polyethylene	9.73	10.40	9,728	10,397	9,599	8,413	7,793	-6.4	8.3	2.9	2.2
PVC and copolymers	8.49	8.35	8,488	8,350	7,971	6,760	6,119	1.7	4.8	4.7	3.3
High-density polyethylene	8.10	8.40	8,100	8,400	7,995	6,085	5,010	-3.6	5.1	5.9	4.9
Polystyrene ^a	5.10	5.19	5,103	5,187	4,780	3,838	4,005	-1.6	8.5	5.9	2.5
Polypropylene	7.35	7.27	7,353	7,274	6,647	4,940	3,841	1.1	9.4	8.3	6.7
TOTAL^b	45.16	46.20	45,160	46,196	43,257	35,585	31,624	-2.2%	6.8%	4.9%	3.6%
SYNTHETIC FIBERS (millions of lb)											
Cellulosics	0.50	0.61	500	614	605	589	930	-18.6%	1.5%	-3.2%	-8.0%
Rayon ^c	0.28	0.40	282	400	414	390	606	-29.5	-3.4	-6.3	-7.4
Acetate ^d	0.22	0.21	218	214	191	199	324	1.9	12.0	1.8	-3.9
Noncellulosics^e	8.52	8.53	8,515	8,526	8,316	7,473	8,419	-0.1%	2.5%	2.6%	0.1%
Polyester	3.59	3.68	3,593	3,680	3,541	3,392	4,178	-2.4	3.9	1.2	-1.5
Nylon ^f	2.74	2.67	2,740	2,670	2,689	2,412	2,721	2.6	-0.7	2.6	0.1
Olefin ^g	1.64	1.59	1,640	1,588	1,494	998	759	3.3	6.3	10.4	8.0
Acrylic ^h	0.54	0.59	542	588	592	671	761	-7.8	-0.7	-4.2	-3.3
TOTAL^b	9.02	9.14	9,015	9,140	8,921	8,062	9,349	-1.4%	2.5%	2.3%	-0.4%
SYNTHETIC RUBBER (thousands of metric tons)											
Styrene-butadiene ^b	1.93	2.00	874	909	850	958	1,378	-3.9	6.9	-1.8	-4.5
Polybutadiene	0.91	0.90	411	407	371	359	397	1.0	9.7	2.7	0.3
Ethylene-propylene	0.57	0.58	260	263	254	215	175	-1.1	3.5	3.9	4.0
Nitrile	0.15	0.17	69	76	69	67	75	-9.2	10.1	0.6	-0.8
Other ⁱ	1.52	1.50	688	679	638	556	502	1.3	6.4	4.4	3.2
TOTAL^b	5.08	5.15	2,302	2,334	2,182	2,155	2,527	-1.4%	7.0%	1.3%	-0.9%

a No longer includes acrylonitrile-butadiene-styrene, or styrene-acrylonitrile resins; historical data are restated. b Totals are for those products listed and may not add because of rounding. c Based on C&EN estimates. d Includes diacetate and triacetate yarn, but does not include cigarette tow. Beginning with 1985, includes rayon yarn. e Excludes aramid after 1982. f Includes olefin film, olefin fiber, spun-bonded polypropylene, and vinyon. g Includes modacrylic. h Excludes high-styrene latex. i Beginning with 1985, includes neoprene; historical data are restated. Also includes butyl; polyisoprene; chlorosulfonated polyethylene; polyisobutylene; and acrylo, fluoro, and silicone elastomers. Sources: Society of the Plastics Industry, Textile Economics Bureau, Rubber Manufacturers Association

Melamine resins were the only component to record an actual production decline in 1988 compared with 1987. Other thermosetting resins showed more modest annual growth in 1989: Unmodified epoxies production rose 4.7%, and urea resins output gained 3.1%. However, production of the largest component of the thermosetting resins category, phenol and other tar acid resins, declined 6.7%.

For the five-year period 1984-89, the plastics segment still grew at a compound annual rate of 4.9%. For the 10-year period 1979-89, plastics output grew at an annual compound rate of 3.6%.

Output of synthetic rubber, another polymer segment, declined 1.4% last year compared with a 7.0% increase the previous year. Produc-

tion of 5.1 billion lb was close to last year's 5.2 billion lb, though still not so good as the high for the decade set in 1979 at 5.6 billion lb.

Two out of five segments of the synthetic rubber category registered overall increases in 1989. One of these, listed as other and including neoprene, butyl, polyisoprene, and other rubbers, had a production increase of 1.3%. The other segment showing an increase was polybutadiene, production of which rose a modest 1.0%. Of the declines, nitrile rubber production showed the greatest, down 9.2%, followed by styrene-butadiene rubber, down 3.9%, and ethylene-propylene, down only 1.1%.

For another polymers group, synthetic fibers, output declined modestly in 1989 following the slow

growth of the previous year. Production of synthetic fibers slipped 1.4% in 1989 after a 2.5% increase the previous year. Imports of finished textiles resumed their upward growth in 1989, putting even greater pressure on domestic fiber producers who supply domestic textile manufacturers. In addition, Avtex Fibers, once the largest U.S. rayon manufacturer, shut down its Front Royal, Va., plant because of mounting environmental and cash flow problems (C&EN, March 19, page 11).

Over the past five years, the synthetic fiber category has grown at a compound annual rate of 2.3%. For the past 10 years, production has declined at an average annual rate of 0.4%.

Marc Reisch